Femtosecond Laser Frequency Combs: A Decade of Diversification

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The combination of femtosecond laser technology, nonlinear spectral broadening, and laser stabilization techniques set off the revolutionary advances in optical frequency metrology witnessed in the past decade. While the use of the femtosecond laser frequency comb as the "gears" of optical atomic clocks has become more routine, the rapid advance of optical standards —in addition to new and exciting avenues of comb-related research—continue to push frequency comb development. In this talk, we will summarize our research advances in the following areas: (1) The use of frequency combs for absolute measurements of optical frequencies and frequency ratios at levels approaching $1x10^{-17}$. In such cases, the contribution of the intrinsic noise of the frequency comb is found to be still 2-3 orders of magnitude smaller. (2) Direct frequency comb spectroscopy and fingerprinting techniques that take advantage of the comb's broad optical bandwidth and precise frequency knowledge to simultaneously probe multiple transistion in atoms and molecules. (3) Optical and microwave synthesis with optical frequency combs, including efforts aimed at the generation of extremely low phase noise 10 GHz signals as well as optical synthesis techniques based on the amplitude and phase control of individual comb elements. And (4), the development of broad bandwidth laser frequency comb sources based on GHz repetition rate Ti:sapphire and Yb-doped tungstates, as well as novel approaches with parametric and electro-optic techniques.